Note on the Job Market, 1995[1]

> This is not a good year for mathematicians looking for a job. Applicants attending the recent winter meeting of the A.M.S. found that research positions available at major universities were scarce and the competition for them was ferocious. Teaching positions at lesser known colleges were in heavy demand, and institutions begging for applicants five years ago could pick and choose. Moreover, this year's graduates found themselves competing with those of previous years who had accepted temporary or undesirable offers and were now trying to improve their standing.
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> "Note on the Job Market", *Notices of the American Mathematical Society*

Those who attended this winter's AMS meeting can readily attest to accuracy of the above description. Only the next line, "Widespread rumors asserted that some departments counted over a hundred applicants for each available position," gives away that the year is not 1995, a year in which many departments count over a *thousand* applicants per position, but 1971. The author goes on to assert that "If we do nothing, then we can expect that by 1975 well over half of our Ph.D.'s will probably have to accept positions in some other field." He suggests that mathematics departments must either restrict enrollments, move towards interdisciplinary training, or face the grim prospect of having mathematicians unemployable in their own field. This prophet of doom is none other than our own Reese Prosser [Prosser, 1971].

In 1995 we face a job market which is as bad as or worse than that of the early 1970's. A number of forces have combined to produce the current crisis, and it is essential that we understand and prepare for the changing environment in which our graduates will be working.

- The number of Ph.D.'s produced per year has grown from a low of 769 in 1985 to 1202 in 1993 (see Figure 2 below).
- Colleges and universities have cut hiring substantially.
- Corporations have been downsizing and moving their research facilities offshore.
- Military labs and defense contractors have reduced hiring in the post-Cold War era.

Examination of these trends suggests that the current employment situation is not a temporary phenomenon, but rather they are a reflection of structural changes in the economy.

We are faced with political as well as economic change. There is currently a movement in Congress to restructure Federal spending on basic research. The deficit has created pressures for accountability for government spending, and many in Congress want more immediate, visible public benefit from Federal research dollars. Congressional science committee chairs have called for allocating an increased share of research budgets to applied, strategic initiatives. These economic and political changes are documented and discussed at length in section 1 below.

What can we do to prepare ourselves for these changes? There have been renewed calls for restricting graduate enrollments, as well as calls for a renewed emphasis on education and a broadening of the curriculum. Sections 4 and 5 give some options for us to consider. These options, as well as more long term strategies, are discussed in greater detail in section 2.

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1 Current Trends in Academic Mathematics

The 1994 Annual AMS-IMS-MAA Survey reveals that as of late September 1994, 14.2% of new Ph.D.'s were unemployed. For graduates of Group II schools (the class containing Dartmouth), the unemployment rate was an alarming 22.4% [AMS Survey, 1994]. These numbers represent the highest rates of unemployment of new math doctorates ever reported by the AMS. The current unemployment situation is a symptom of large-scale changes underway in the sciences and in the US economy. Despite the current job-market difficulties, the Dartmouth math department has done exceptionally well in finding placement for its graduating majors and doctoral students. We must ensure that we continue to be prepared for the changing economic and political changes facing our discipline.

1.1 Causes of the Current Job-Market Situation

The present levels of Ph.D. unemployment have multiple, interrelated causes.

- During the late 1980's, the number of Ph.D.'s produced grew from a low of 726 in 1984-85 to a peak of 1202 in 1992-93. An influx of foreign students accounted for 72% of this increase [AMS Survey]. The more cynical attribute much of this increase to "The Myth," a badly flawed 1987 NSF study forecasting a future shortfall of 675,000 natural scientists and engineers, but it is clear that this is not the full story.

- Colleges and universities, under intense financial pressures due to cutbacks in federal spending on higher education as well as the recent recession, have been reducing faculty sizes. The American Council on Education's 1993 Campus Trends report indicates that 40% of doctoral-granting institutions have procedures underway to cut back on the number of full-time faculty, mainly through attrition [ACE, 1993]. The AMS reports that there were 31% fewer positions offered in math departments in 1992-93 than in 1989-90 [AMS Survey]. Universities are making up lost teaching capacity with temporary and part-time workers, with 52% of ACE surveyed institutions reporting extensive use of part-time faculty (i.e. more than one-fourth of courses in these institutions were taught by part-time faculty) [ACE, 1993].

- Corporations, faced with an increasingly competitive global economy, have been paring back research and development budgets. In addition, global companies which once hired research mathematicians no longer have to look to U.S. labs to provide the best researchers. Sun Microsystems, for example, has begun to fund Russian scientists for some of its research in parallel operating systems; Lotus has an extensive software development facility in Bangalore, India.

- The budgets of military research labs and defense contractors have been slashed as a result of the end of the Cold War.

- The total number of scientists has been growing exponentially at a rate faster than the growth of the population. David Goodstein, provost of Cal Tech, points out that the current oversupply of scientists is the inevitable result of this disparity in growth rates [Goodstein, 1993].

1.2 Precedents and Predictions

Mathematics experienced a similar but less severe job crunch in the early 1970's. Fall unemployment of new Ph.D.'s climbed from 7.5% in 1970-71 to a peak rate of 13.7% in 1974-75 (see Figure 1), then gradually decreased to a stable level of roughly 5% in 1977-78 [AMS Survey].

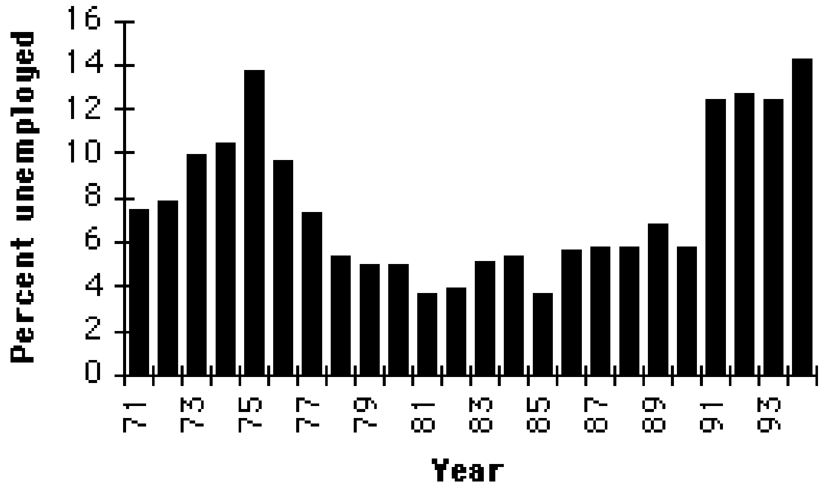

Figure 1: Fall unemployment rate for new mathematics Ph.D.'s.

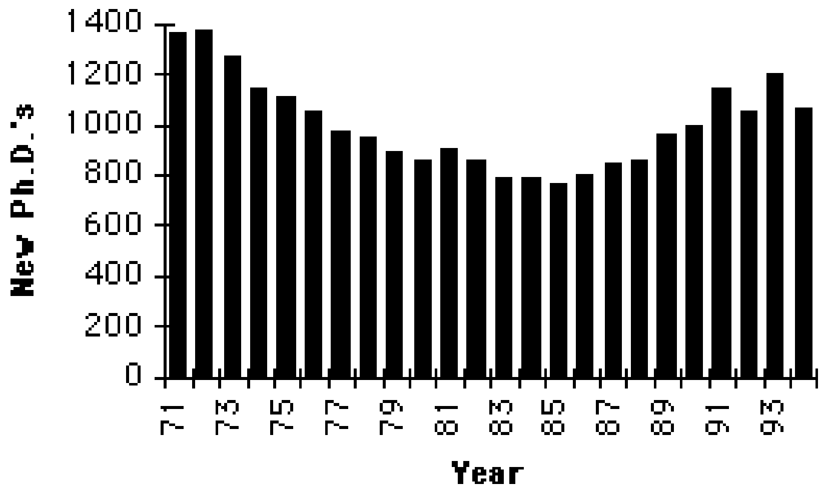

Figure 2: Number of new mathematics Ph.D.'s per year.

A study of a similar unemployment peak for physicists in the early 1970's [Freeman, 1989] suggests that the crisis of the 1970's was resolved largely due to market forces. The low salaries and difficulty in finding jobs in physics that resulted from the oversupply of Ph.D.'s proved a strong disincentive for students to enroll in physics Ph.D. programs. A similar decline in mathematics graduate enrollments is suggested by the decline in Ph.D. production in the first half of the 1970's as shown in Figure 2. Sharp reductions in federal funding for graduate students in 1968 further contributed to declining graduate enrollment. As a result, Ph.D.-program enrollment plummeted during the 1970's, falling by 19% in Group I schools and 31% in Group II schools. [AMS Survey, 1976]

There are a number of important differences between the situation today and that of the 1970's. Mathematics departments have been reluctant to pare back graduate enrollments over the past decade, and have made up for declining numbers of American graduate students by enrolling foreign students. Of the Ph.D.'s granted by U.S. universities in 1993-94, 56% were earned by non-U.S. citizens. In contrast, only 28% of the Ph.D.'s granted in 1973-74 were to non-U.S. citizens. If foreign student enrollments are less responsive to economic conditions in the U.S. than are U.S. student enrollments, the market forces that helped to ease the crisis in the 1970's will provide significantly less relief. First-year full-time graduate student enrollments were relatively stable from 1988 to 1992, which suggests little alleviation of present conditions until at least 1997-98 barring an increase in the Ph.D. program attrition rate. The beginnings of a decline in enrollments may be underway, however, as the number of first-year doctoral students in the fall of 1993 decreased by 7% from the fall 1992 level [AMS Survey].

Large cutbacks in federal support for graduate students in 1968 were a second force which contributed to the decline in graduate enrollments during the early 1970's, and eventually brought relief to the job market. As a result of these cutbacks, universities absorbed much of the cost of funding graduate students (at the price of tuition hikes and increased numbers of huge lecture course offerings). The result is that mathematics graduate enrollment levels today are far less influenced by federal funding than they were in the 1970's. [Herman, 1993]

A third force that helped bring an end to the job market crisis in the 1970's was the end of the recession in 1975-76. Although the current economic recovery has been underway for two years, the unemployment rate for new Ph.D.'s has continued to climb. The decline in available academic jobs experienced over the last 5 years appears to be a permanent decline rather than a temporary effect of hard economic times. Substantially increased federal funding to universities does not appear to be forthcoming due to the austerity imposed by the current federal budget deficit. Although university enrollments are projected to increase slowly after 1996, continued financial pressures on universities probably mean that the necessary increase in teaching capacity will be generated by increasing teaching loads of existing faculty and by hiring more part-time faculty [Hecht, 1994]. Even if employment returns to more acceptable levels, the problem of underemployment is likely to persist.

As a result of the end of the Cold War and the globalization of the economy, there have been cutbacks outside of academia as well. Federal research labs are unlikely to resume their levels of hiring of the late 1980's with the spectre of the Soviet empire fading, and corporations have been paring back research and development budgets as they attempt to downsize.

The AMS Task Force on Employment's 1992 report projects a demand of roughly 790 Ph.D.'s per year in the U.S. market through 2008. These estimates optimistically assume faculty retirement by age 65, full replacement of retirees, and stable corporate hiring [AMS Employment, 1992]. Current graduate enrollment figures suggest that Ph.D. production will remain in the neighborhood of 1100 Ph.D.'s per year for the next 3 to 4 years. If the percentage of new Ph.D.'s that seek jobs abroad remains relatively steady at 15%, then the jobless rate for new Ph.D.'s will most likely continue to remain in the neighborhood of 13%. Since unemployed and underemployed Ph.D.'s from past years continue to apply for jobs, the 13% figure may well be a low estimate.

1.3 Political Changes

Overshadowing trends in the job market are impending changes in federal funding of basic research. The contract which has governed government-university relations for the past 50 years derives from Vannevar Bush's 1945 report *Science–the Endless Frontier*, has been pronounced dead by both university and Congressional leaders [NRC, 1994]. Central tenets of the Bush vision as they have been interpreted by the scientific community, according to Rep. George Brown (D-California), former chair of the House Committee on Science, Space, and Technology, include:

- Basic research is the source of fundamental knowledge that eventually leads to innovation, technology development and economic growth.
- Basic research should be carried out primarily in universities in isolation from political constraints for applications-oriented management.
- Applied research restricts creativity and serendipitous discovery.
- Academicians must perform cutting-edge research in order to be effective educators (this is the support link between teaching and research).
- The connection between research results and societal benefits is indirect, which implies that we accept as an article of faith that more high-quality research will necessarily translate into more benefits for society at large. [Griffiths, 1994]

The Bush contract has been pronounced dead in speeches in Congress and by university officials. Although members of Congress are careful to note the value of basic research, science is being castigated for failing to translate advances in basic research into national economic performance, and universities are being berated for focusing too much on research and not enough on education. In a recent speech, Rep. Patricia Schroeder (D-Colorado) stated, "Cutting through all the 'excellence' and 'quality' rhetoric reveals one very clear point: the focus in higher education today is on research, not teaching. This fact has not been lost on the professors. If you don't believe me, go ask one yourself. However, don't look for a professor in the classroom; it's unlikely you will find one." [O'Malley, 1993] There is a call for a greater accountability on the part of researchers as to how public funds are spent. If scientists are to be funded by the public, especially in a time when public funds are scarce, the public must benefit from its investment.

The Clinton policy document *Science in the National Interest* may be indicative of the future of federal funding of the sciences. The three key policy goals outlined in this document are to

- Enhance connections between fundamental research and national goals.
- Stimulate partnerships that promote investments in fundamental science and engineering and effective use of physical, human, and financial resources.
- Raise scientific and technological literacy of all Americans. [Clinton, 1994]

Under this new government-university contract, a greater emphasis will be placed on funding research which addresses national goals, on spurring university-industry partnerships to stimulate technology transfer, and on educating all members of the population. The report acknowledges and stresses the importance of fundamental, non-applied research, and emphasizes that basic research will continue to be funded. Particularly telling, however, is a recent speech by Sen. Barbara Mikulski (D-Maryland), former chair of the Appropriations Subcommittee which funds the NSF. Mikulski states,

> I truly believe that there is a new paradigm emerging in how science is conducted and how science policy is organized. It's based upon the principle that science should lead to the new ideas and new technologies which should lead to jobs.... To regain the ground we have lost over the last two decades, we must seek models of collaboration between our universities and the private sector. We must focus our science investments more strategically–around national goals that are important to economic growth and whose results will ultimately improve people's day-to-day lives.... [the Subcommittee] said that 60 percent of what NSF research should go for should be strategic.... It does not mean that every NSF or NIH grant must result in six patents and four commercial licensing agreements.... It does mean that we should be spending more than half of our basic research dollars in areas we consider strategic. [Mikulski, 1994]

It is unclear what stance the new Congress will take on the funding of basic research. Some Republicans see the encouraging of (non-military) research in areas of national interest as a form of industrial policy, to be avoided at all costs. On the other hand, strategic, goal-oriented research is consistent with the Republican Contract with America's emphasis on greater accountability in the spending of government funds. Notably, Representative Steven Schiff (R-New Mexico), the new chairman of the House panel that oversees the NSF and basic research, believes that "government [sponsored] research should be more goal-oriented," and he wants grants to universities to reflect this emphasis [Science, 1995].

2 Dartmouth's Course of Action: Some Options

Will Dartmouth be prepared for the economic and political changes affecting our discipline? We face the prospect of

- Diminished academic opportunities for our graduates.
- Reduced graduate enrollments.
- A restructuring of Federal funding.

Three basic responses have been called for by policymakers and educators.

- "Birth control."
- Refocusing on education.
- Broadening of the curriculum.

We examine each of these options in turn and discuss their implications for Dartmouth.

2.1 "Birth control"

Kurt Gottfried, chairman of the physics department at Cornell University, has called for physics departments across the country to reduce the number of graduate students and to use the savings to fund postdoctoral positions [Gottfried, 1994]. Cornell has reduced the number of students accepted into its program from 40 to 19, and about a dozen of the top physics departments are taking similar steps [Gibbons, 1994].

Others advocate more drastic measures. David Goodstein, provost of Cal Tech, William Bowen, president of the Andrew W. Mellon Foundation and former president of Princeton University, and Neil Rudenstein, president of Harvard University, say that the number of Ph.D. programs must be reduced. In their 1992 book, *In Pursuit of the Ph.D.*, Bowen and Rudenstein call for universities to shut down programs producing fewer than 4 Ph.D.'s a year [Gibbons, 1994]. Dartmouth's program, while very successful, is not far from this threshold.

2.2 Refocusing on Education

There is a sense that universities have lost sight of their primary goal of educating students, as exemplified in Rep. Schroeder's comments above. Philip Griffiths, director of the Institute for Advanced Study, writes,

> ...I suggest universities should fundamentally rethink their missions. Another unintended effect of *The Endless Frontier* has been a redirection of mission of our research universities. Although usually stated as having the dual missions of teaching and research, the reality is that in the so-called research-intensive universities the education mission has taken a second seat to research. The research grant is the badge of honor, and the professor who devotes primary energy and creativity to teaching is *de facto* penalized and often looked down upon by peers. [Griffiths, 1994]

Dartmouth's strong emphasis on teaching has prevented many of these problems from occurring here. However, a broader reading of the university's mandate to educate is that our department has a responsibility to educate *all* students and not just the future specialists in our field. In this respect, we have room for improvement. The 1993 Report of the Mathematics and Computer Science Review Committee [Review, 1993] notes the "serious and innovative effort" spent on the undergraduate curriculum, but raises serious concerns about the drop in enrollments over the past 15 years. The number of annual math credits taken has fallen by 31% between 1981-82 and 1993-94, and the greatest decline has been in introductory courses for non-majors.

In part, the decline in course credits taken is a reflection of a national trend. Indeed, Harvard labor economist Richard Freeman makes a convincing case that the number of graduating physics majors in any given year is strongly influenced by the economic conditions for physicists two years before [Freeman, 1989], which bodes especially ill for future enrollments should the same be true of mathematics majors.

While there is little the department can do to affect national interest in mathematics, our enrollment figures suggest that departmental actions have a significant effect on course enrollments, especially on the enrollments of the non-majors who make up the bulk of our clientele. For example, the streamlining of the calculus sequence in 1985-1988 coincides with a sudden, dramatic decrease in calculus enrollments. Similarly, the switch of calculus texts to Greenspan, Benney, and Turner in 1990-91 corresponds to a sharp downturn in calculus enrollments, mostly from Math 8, the second term calculus course. Although the relationships between these departmental actions and calculus enrollments are not necessarily causal, they are certainly suggestive of the magnitude of the effect that changes in the curriculum might have. On the positive side, the introduction of the CHANCE course in 1990 has led to a substantial increase in survey course enrollments.

If we are careful to address the needs and interests of our students, we can attract larger audiences. The national decline in interest in mathematics means that the burden of proof of the importance of our courses is upon us. It is essential that we work to ensure the relevance of our teachings and that we communicate the importance of our discipline.

In addition to declining student interest, part of the decrease in enrollments has resulted from other departments' perceptions that our courses are inappropriate for their needs. The departmental review cites a consistent concern on the part of other departments that "their students were being taught theory at the expense of practical skills." For example, the material in Fourier Series and PDE's (the old Math 33), once a class of 140-170 students per year, is now being taught at Thayer. Although enrollments in ODE's (Math 23) have roughly compensated for the loss, the fact remains that the Engineering School has found it necessary to take responsibility for teaching this material. Statistics for Design of Experiments (the old Math 30), a class averaging 16 students per year, now averages 6 students per year as an Introduction to Linear Models.

There are several things we can do to stop the downward trend in enrollments. In the long term, we can redesign our offerings in order to fit more closely with the needs and interests of a broader group of students. The Mathematics Across the Curriculum initiative seeks to accomplish just such a redesign, and it is a laudable step towards increasing the number of beneficiaries of the mathematics department. It is important that we implement the central ideas in the initiative regardless of the availability of NSF funding for the initiative.

An immediate step we can take to adapt our courses more closely to majors in other departments is to **offer specialized versions of the basic calculus/linear algebra/ODE sequence**. Students could be offered a choice between more applied courses and more theoretical, depending on their interest. Multivariable calculus could be taught with an emphasis on the vector calculus necessary for the study of electromagnetic fields. Alternatively, elements of continuous probability could be introduced in order to motivate multivariable calculus problems. Linear algebra could be given as a proof-oriented course for math majors, and as an applied, problem-solving-oriented course for non-majors or applied math majors.

A second short-term step we can take to extend the benefits of mathematics education to others is to merchandise our wares more effectively. By designing and marketing custom mathematics minors for students in other majors, we can give these students an idea of what mathematics courses are important for their fields. A particularly effective means of conveying the utility of various course offerings would be to ask our recent graduates to list their most valuable math courses and to describe how they have used their mathematics education in their careers. The packaging of the courses into different minors provides a certification of basic mathematical competence which can be valuable in a job search or in graduate school applications. By **refining the existing math minors**, we can make them more accessible and relevant, and by **explaining and advertising these minors** to freshmen we can ensure that these minors become a valuable educational experience for students outside our department. For course credit purposes, the fundamental relationship

$$3 \text{ math minors} \approx 2 \text{ math majors} \tag{1}$$

is an important one to remember.

2.3 Broadening the Curriculum

In a recent editorial in *Science*, Mary Lowe Good, Undersecretary for Technology of the Department of Commerce, and Neal Lane, Director of the NSF, recommend, "Graduate education in science and engineering must better reflect the many profound changes in the economy generally and in the labor market for professional scientists and engineers specifically." [Good, 1994] The AMS Task Force on Employment's 1992 report notes,

> ...the mathematics graduate departments need to be sure that their programs provide their doctorates with sufficient flexibility that if one job market is restricted or closed down their doctorates are in a position to enter other job markets.... As long as mathematicians remain dependent on academia as the near-exclusive employer of their talents they must anticipate repetitions of employment shortfall as at the present time. Further, when a group narrows its employment possibilities it necessarily restricts the size of the income of its members. [AMS Employment, 1992]

Similar calls were made in the 1970's employment crisis. In a 1971 *Notices of the AMS* Gail Young wrote, "What I do believe is that we must make fundamental changes in the nature of graduate work in mathematics which will prepare most of our students for something other than academic life." [Herman, 1993] This is not to say that the teaching of traditional, pure mathematics should be reduced, but rather that other options should be made available for people who may be inclined to pursue non-academic careers. Young's advice has been ignored for two decades, and we now face economic conditions which are similar or worse than those of the early 1970's.

It is essential that we examine our graduate and undergraduate mathematics programs to ensure that those bound for jobs outside of academia will be adequately prepared. Our undergraduate and graduate programs provide excellent preparation for teaching and academic research careers, but we must recognize that not all of our graduates end up in academia. Fewer than 25% of the math majors who graduated between 1990 and 1992 were known to be enrolled in graduate programs in mathematics as of the spring of 1993. According to the department's 1993 self study, the most common career choice for this group of students is some form of financial analyst or actuarial work.

We can gain a better understanding of the needs of industry (here defined broadly) by cultivating relationships with local corporations which are mathematically oriented. SIAM's Mathematics in Industry study states that "interdisciplinary work and work done outside academia, by both students and faculty, must be valued and rewarded." [SIAM MII, 1995]. Our department has close ties to several companies through alumni employees and through technology transfers. Company A, a medical imaging company in Cambridge, is currently exploring several algorithms developed here. Company B, also in Cambridge, employs Person X and Person Y, two recent Ph.D. students with advisors in the department. Company B's Human Resources department has recently written to members of the department that, "if there are more students like Person X and Person Y we would love to hear from them!" Person Z, another recent advisee of a Dartmouth mathematician, is being courted by Company C in Palo Alto. All three of these companies afford rich opportunities for collaborative work. By creating **summer industrial research internships** for sufficiently advanced undergraduates and graduate students, we can enhance significantly our students' education and employability. Another way to build closer relationships with industry would be to create a **two-year industrial postdoctoral position**, jointly funded by Dartmouth and industry. The postdoc's time would be divided between Dartmouth and industry in order to provide a two-way flow of ideas. Duties of the postdoc could include assistance in the design an applied/industrial graduate math curriculum which builds on Dartmouth's existing strengths, and designing and teaching industrial problem solving courses to undergraduates in accordance with the Mathematics Across the Curriculum initiative.

Finally, we can improve our program by **strengthening and refining our existing Applied Math option** for the undergraduate math major, and by considering the addition of a similar option to the Ph.D. program. SIAM's Mathematics in Industry project has found that

> nonacademic employers are not interested in hiring the mathematics graduate whose credentials are limited to depth in one area of mathematics. Individuals who succeed in business, industry, and government, say these employers, are flexible people who have demonstrated their ability to wrk in teams; in addition to a broad interdisciplinary background and computing skills, they have communication and interpersonal skills and a genuine interest in the organization's mission.... curricula should be broadened to include experience in problem formulation and problem solving, interdisciplinary work, and computing. [SIAM MII, 1995]

Listed below are some suggested principles for a restructuring of our applied math option to address the need for both breadth, depth, and interdisciplinary work. A detailed sketch of a major implementing these principles is attached.

Key elements of an Applied Math program include:

- Basic analytical tools, e.g. calculus, linear algebra, ODE's, and real analysis
- Basic tools for data analysis, e.g. probability and statistics
- Computational skills, e.g. C++, numerical methods
- Intellectual depth in some area, e.g. analysis, combinatorics, probability and statistics, mathematical physics, scientific computing, modeling, or signal processing

3 Conclusion

Our profession is faced with profound economic and political changes. If we fail to adapt, we risk a continuing decline in enrollments, diminished opportunities for our graduates, and a decreased share of university resources. If, on the other hand, we communicate the importance of our discipline more effectively, we become more responsive to the educational needs of our students, and we broaden our curriculum, we will meet the future prepared.

4 Recommendations to the Undergraduate Program Committee

- Offer specialized versions of the basic calculus/linear algebra/ODE sequence

  By offering specialized versions of our basic calculus/linear algebra/ODE sequence, we could give students a choice between more applied courses and more theoretical, depending on their interest. Multivariable calculus could be taught with an emphasis on the vector calculus necessary for the study of electromagnetic fields, for example. Alternatively, elements of continuous probability could be introduced in order to motivate multivariable calculus problems. Linear algebra could be given as a proof-oriented course for math majors, and as an applied, problem-solving-oriented course for non-majors or applied math majors. Ordinary differential equations could be taught with an emphasis on models in mathematical biology.

- Create custom math minors for majors in other departments

  By designing and marketing custom mathematics minors for students in other majors, we can give these students an idea of what mathematics courses are important for their fields. The packaging of the courses into different minors provides a certification of basic mathematical competence which can be valuable in a job search or in graduate school applications. Designing these in tandem with the relevant departments would allow us to add the seal of approval, "As recommended by the X department," to our ORC minor descriptions.

- Put in place a mechanism for regular advertisement of these minors

  As discussed below, there has been a decline in interest in mathematics at the national level. The burden of proof of the importance of our course offerings is therefore upon us. A comprehensive description of different major and minor options and how they fit into various career paths which would be distributed in introductory math courses would allow us to sell ourselves to a captive audience. A particularly effective means of conveying the utility of various course offerings would be to ask recent graduates in various career tracks to cite their most valuable math courses and to describe how they have used what they have learned.

- Remodel the applied math major option

  We can improve our existing applied math major by requiring computer skills, encouraging greater intellectual depth, and by giving credit for related courses from engineering, physics, chemistry, and economics.

- Negotiate with local mathematically oriented companies to create summer internships

  By cultivating relationships with industry (defined broadly) we can bring about an exchange of ideas which will help us to better understand the needs of those students bound for jobs outside of academia. Work experience would also enhance the employability of our undergraduates.

- Pursue an industrial postdoctoral position jointly funded by industry

  An industrial postdoctoral position will enable the department to build an important working relationship with local industries. Responsibilities of such a position could include the design of applied/industrial mathematics courses for the Mathematics Across the Curriculum initiative, as well as the supervision and organization of undergraduate and graduate internships. Furthermore, such a position would provide a valuable exchange of ideas between the academic community and industry.

5 Recommendations to the Graduate Program Committee

- Rewrite the graduate "contract" to incorporate support for new and/or higher-level courses

  Changes in our course offerings require substantial effort on the part of faculty members. Having graduate students provide support for new courses and for large upper-level courses gives these students an opportunity to have some teaching experiences in a closely supervised setting, gives undergraduates more instructional attention, and encourages the faculty to enlarge upper level courses and to create new courses. Graduate students would work with a faculty mentor and could participate in course design and give occasional, carefully supervised lectures. They could also give recitations, tutorial sessions, supervise labs, and share in grading for courses for which, due to the novelty or the advanced level, there are few if any undergraduates available to provide these services.

- Negotiate with local mathematically oriented companies to create summer internships

  By cultivating relationships with local industry (defined broadly) through graduate summer internships, we can bring about a stimulating exchange of ideas and problems. BBN in Boston has already expressed interest in our students. Work experience would also enhance the employability of our graduate students.

- Restructure course and qualifier requirements for more applied graduate students

  More applied coursework would provide more appropriate skills for students interested in working in applicable areas, such as those studied by Ken Bogart, Dorothy Wallace, or the Prosser/Healy/Rockmore group. Additional courses could come from the computer science department as well as the Thayer School.

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